Guidelines for DIRECT – SEEDING LOBLOLLY PINE

W. F. Mann, Jr.

H. J. Derr

Cover:

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The development of methods for direct seeding loblolly pine was greatly facilitated by the cooperation of the Louisiana Forestry Commission and many of Louisiana's industrial landowners, especially International Paper Company, Bodcaw Company, T. L. James & Company, Crosby Chemicals, Inc., Hillyer-Deutsch-Edwards, Inc., and Roy O. Martin Lumber Company. These organizations provided seed, equipment, labor, and sites for most of the tests.

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Small mammals cause heavy seed losses on most sites unless endrin is used in the repellent coating.

Direct seeding is a valuable new regeneration technique that will supplement planting and natural seeding. Correctly used, it is cheap, fast, and reliable, but for maximum success with greatest economy the forest manager must learn where this method is better adapted than alternative ones.

Reliable techniques for seeding loblolly pine have been developed and perfected by the Alexandria Research Center over the past 10 years. The idea of sowing directly in the field is old, but putting it into practice required finding repellents to protect seed from important predators. The initial breakthrough came in 1953, when several chemicals for coating seed proved highly successful in repelling birds. After that, research was aimed at developing a practical method of checking rodents and insects; by 1956, enough tests had been completed to prove that the addition of a commercial insecticide to the coating would guard against these predators.

The validation of a combination repellent signaled the beginning of large-scale loblolly seeding in Louisiana. Since 1957, 100,000 acres have been seeded by more than 25 different landowners in the State. A wide variety of soil and cover conditions has been successfully sown, giving a broad base of practical experience to confirm research findings. Better than 95 percent success has been achieved overall, and the few, scattered failures have resulted primarily from serious deviations from recommended procedures.

The guidelines offered here were formulated from a large number of detailed studies on small plots, and are supported by observations on most of the commercial operations in the State. Enough trials have been made in neighboring states to show that the information is applicable to reasonably broad areas without change. It is anticipated, however, that adjustments in some of the prescriptions will be necessary to fit local conditions in more distant parts of the loblolly pine range. The most obvious example is the optimum date of sowing, which varies from 3 to 5 weeks throughout the broad range of the species. The possibility of other deviations is pointed out in appropriate sections.

As the southern pines differ in their response to the basic factors affecting germination and survival, no attempt should be made to apply the rules contained here to other species. Detailed guidelines for direct seeding longleaf pine were published by the authors in 1959, and interim recommendations for slash pine are available in several publications.

This paper is intended to cover all of the steps from selection of sites to evaluation of the newly established stands. Each phase is presented in sufficient detail to permit foresters inexperienced in seeding to plan and execute a commercial operation. No literature is cited in the text, but some references for further reading are listed at the end of the text.

ADVANCE PLANNING

Appraisal of site

Before plans are made for regenerating an area, it must be determined if direct seeding is the most practical method and which species is best adapted to the site.

Seeding on adverse sites is the cause of more failures than any other single factor. There is often a tendency to try direct seeding where planting has been unsuccessful. But an area should not be seeded if it cannot be planted with high survival (this statement does not necessarily apply to rocky sites where planting is impractical). The recommended procedure for starting a direct-seeding program is to restrict initial trials to average or better sites, and work toward more difficult ones as experience is gained.

Three situations should be avoided in any

direct seeding. First are steep, eroded sites where seeds are easily washed away. Second are upland soils with coarse, sandy surface layers that dry out and crust over within 4 to 8 hours after a rain. Rapid loss of moisture from the surface sharply reduces germination, although the sites may be quite productive otherwise. Furrow-seeding machines that bury seed ½ to 1 inch deep are being tested on such sites, but broadcast methods cannot be recommended. Third are sites subject to spring floods. Viability of loblolly seed is reduced by submergence for as little as 2 weeks, and still shorter periods lessen the effectiveness of the repellents.

Loblolly seeding has been successful under a wide variety of cover conditions—none have yet been found that limit applicability of the method. Generally, cover situations fall into two broad categories, depending on the amount of grass. The first includes open, cutover sites and old fields with dense grass (fig. 1). For consistent success on such areas, disking or other mechanical seedbed preparation is required to reduce competition for soil moisture during the critical first year and to prevent seedlings from being smothered by the grass.

The other category consists of upland sites dominated by low-grade hardwoods (fig. 2) and poorly stocked stands of loblolly-shortleaf and mixed pine-hardwoods. While these areas are the most costly to plant, they are the easiest and cheapest to seed. A burn to remove excessive litter ordinarily is adequate site preparation, because the native sod is too sparse to hamper survival or growth of pine seedlings.

Figure 1.—**Heavy grass on open areas competes severely with first-year seedlings.**

Figure 2.—**Areas with dense hardwoods are good seeding chances, because grass is never a problem.** (Photo by Louisiana Forestry Commission.)

The natural range of loblolly extends along the Coastal Plain from New Jersey to Florida and westward to the eastern part of Texas; it includes most of the Piedmont. Within this range loblolly grows vigorously on many types of soils, but excels on moist, well-drained sites. On extremely wet or dry sites other species usually fare better. Slash pine is preferred on the "flatwoods" soils of the lower Gulf Coastal Plain where a tight, impervious subsoil lies within 4 to 12 inches of the surface and the water table is high most of the winter. Deep coarse sands, such as those in western Florida, are also poor choices for loblolly, for growth is slow and tipmoth infestation is apt to be severe. Longleaf, and possibly sand pine, are the best species for droughty sands in the southern part of the range; in the northern extremes, shortleaf is often the best choice.

The chances are good that loblolly will grow satisfactorily wherever it occurred in virgin stands. If past performance is unknown, the vigor of young natural reproduction on the site, or on similar ones nearby, may serve as a guide.

Site inspection and protection

Sites should be chosen and inspected at least 8 months in advance, so that plans can be made for seedbed preparation, seed pro-

curement, and special protection. A map is needed for the examination, and aerial photographs are helpful, especially for tracts over 500 acres. Items to note or map include severe grazing by livestock; infestations of town ants, harvester ants, and pocket gophers; signs of unusual predators; areas with adequate natural reproduction; condition of the seedbed and need for burning; and advantageous ridges for flagging if aerial sowing is contemplated.

Light grazing by cattle is not usually a hazard, but in heavy concentrations animals cause damage by trampling as well as browsing. All forms of seedbed preparation—burning, furrowing, and disking—as well as hardwood control attract livestock from several miles about. The hazard from cattle is greatest on areas which are so small that the congregation of a few animals results in an overgrazing condition. Damage rarely is serious on tracts of 1,000 acres or more.

It is necessary, then, to appraise the number of livestock using nearby areas, as well as those on the area to be seeded, to estimate the severity of grazing after cultural treatments are initiated. Danger of overgrazing may be minimized by burning more acreage than will be sown, or by burning nearby tracts as a diversionary measure. In severe situations temporary fencing may be needed until seedlings exceed 5 feet tall, when they are safe from grazing animals.

Town ants, found only in portions of Louisiana and Texas, destroy seed and seedlings. Colonies should be fumigated in the winter before sowing, and annually thereafter until the pines are no longer vulnerable. Harvester ants inhabit sandy sites throughout the South. If numerous, nests should be poisoned before sowing. Since these ants attack only seed, and not seedlings, follow-up treatments are unnecessary.

Pocket gophers, often called salamanders, feed on the roots of young pines. In a few years their inconspicuous damage can seriously deplete a pine stand. They should be killed (by placing poisoned grain in underground tunnels) prior to seeding, with annual retreatments if inspections indicate a resurgence of the population. When populations are high, large mammals such as deer or rabbits can heavily damage young seedling stands. Assistance of State game technicians should be sought when game animals are a problem.

Woods hogs occasionally harm loblolly seedlings, and will bear close watching.

SEEDBED PREPARATION

The choice of seedbed depends largely on cover and site conditions, and on probable distribution of summer rains.

As previously indicated, disking is unnecessary on areas where hardwood trees or brush shade out most of the grass. Burning is required only if the litter is deep enough to prevent seed from reaching mineral soil. Specific criteria on litter depth have not been developed, but a good rule-of-thumb is not to burn unless ground fuels are heavy and continuous enough to carry fire over the entire area.

The best time to burn is in the autumn when about half the leaves have fallen from the hardwoods and when the litter is dry. Freshly dropped leaves help carry the fire where the old litter is matted down. If the weather is wet at this time, burns can be made at any time during the winter.

Landowners who lack the necessary equipment for burning or are unwilling to risk spreading fire to adjacent land may resort to seed spotting, described in the section on hand sowing.

Open, treeless areas with a heavy sod should be disked for consistent success. Summer disking—anytime from July to October—is preferred because the best kill of grass roots is obtained if the sod is turned when the weather is hot. Moreover, allowing time for the soil to settle minimizes seed losses from silting, which have been as high as 50 percent on fresh disking.

Burning off the accumulation of dead grass facilitates pulverization of the soil by the disk

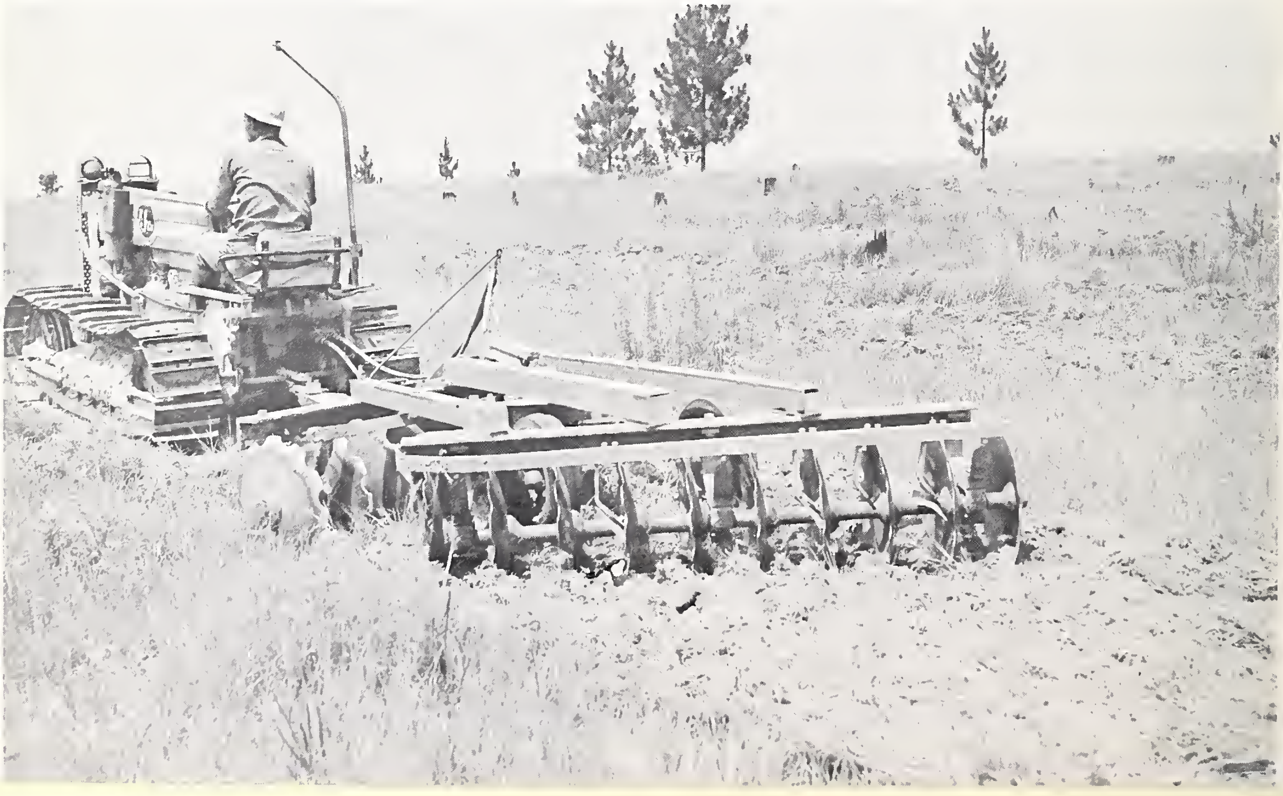
Figure 3.—**For best pulverization, heavy roughs should be burned before they are disked.** (Photo by Louisiana Forestry Commission.)

(fig. 3). The burn can be made immediately before disking or during the preceding winter.

A heavy-duty offset disk, cutting about a 7½-foot swath, does a good job at a reasonable cost. It can be pulled by a light crawler tractor of the kind commonly used for planting or to pull fire plows. A single disking reduces the grass competition enough to facilitate pine establishment. Costs can be reduced if disking is done in strips spaced 6 to 8 feet apart edge-to-edge (fig. 4). In commercial operations, expenses of strip disking have ranged from $1.50 to $2.00 per acre when light tractors such as John Deere models 420 and 440 were used.

Plowed furrows have not proved satisfactory, although they may have limited utility under special conditions. Their main drawbacks are that seed is washed away on sloping

Figure 4.—**In a light rough, a single pass with an offset disk prepares strips for seeding.**



ground or killed by flooding on flat, poorly drained sites. Furrowing has been effective in several operations on flat, well-drained, sandy sites where flooding and washing were minor. Furrow seeding, a technique entirely different from sowing in plowed furrows, will be discussed in the section on methods of sowing.

There is an intermediate condition between the open, grassy areas and those with a heavy cover of hardwoods. Frequently hardwoods grow as individuals or in small groups, and the grass is light beneath them but fairly dense in openings (fig. 5). Here the soil type

Figure 5.—**Scattered hardwoods often have patchy stands of heavy grass that may need disking if the soil is droughty.** (Photo by Louisiana Forestry Commission.)

largely determines the kind of seedbed to prepare. Sandy or droughty soils should be disked. On soils with good moisture, disking is unnecessary but burning may be desirable to reduce grass and litter.

Open areas or those with a partial stand of hardwoods are often direct seeded with no more site preparation than a burn, even though disking is recommended. The chance for success, however, is substantially less than on disked sites. In a wet summer enough seedlings will survive and outgrow the grass to form a good stand. In dry years mortality is heavy and stocking is further depleted as grasses overtop and smother seedlings. Summer droughts of 4 to 6 weeks are common in Louisiana, and in adverse years dry periods may last for 2 or 3 months; satisfactory stands have nearly always been attained on disked strips, but seedings on fresh burns or light roughs have succeeded in only about 5 years out of 10. These odds may differ in other parts of the loblolly range, especially in the southerly and easterly portions where summer rains are more evenly distributed. Where droughts are uncommon, local tests may be advisable to verify the need for seedbed preparation.

Disking may be justified by improved growth even if not needed for protection against drought. In 9-year-old direct-seeded stands in Louisiana, dominant loblolly pines averaged 19.2 feet tall on disked strips, while those established on a light rough were 15.2 feet (fig. 6). The difference represents almost 2 years' growth—more than enough to offset the cost of disking.

Figure 6.—**Disking for seedbed preparation not only protects against first-year drought but also improves growth. At age 9 years the trees at left, which were seeded on disked strips, are 4 feet taller than those at right, which were established on a light rough.**

SEED PROCUREMENT

Procurement of seed should be arranged well in advance, preferably as soon as the site is selected and inspected. At that time, the amount of seed can be determined from the acreage and the indicated sowing rate.

Of the several ways to obtain seed, the easiest is to buy it from a commercial dealer. Prices have ranged from $2.50 to $4.50 per pound in recent years, depending on the abundance of seed and the quantity purchased.

Buying has several disadvantages. First, seed from a local source is difficult to obtain unless a commercial kiln is nearby; yet seed source probably is more important for loblolly than for any other southern pine. Loblolly from nonlocal sources may grow more slowly than the native race, have poorer form, or be more susceptible to diseases or insects. A second disadvantage of buying seed is the probability that it will be from trees with inferior form or growth rate. Ordinarily, commercial dealers buy cones from small collectors who pick largely from inferior trees removed in improvement cuttings or limby trees that are easy to climb (fig. 7).

When purchasing seed, minimum standards for viability, soundness, purity, and moisture content should be specified. Carefully handled seed, whether fresh or stored, should have at least 80 percent germinability on a sound seed basis. Lower viability suggests that the lot has been mishandled and its vigor has started to decline.

Seed should be cleaned until empties are 10 percent or less by number and impurities are under 2 percent by weight. Trash must be removed, because it may clog sowing machines and thus cause poor seed distribution.

A moisture content of 10 percent or less should be specified, both to get as nearly as possible the maximum number of seeds per pound and to avoid the need for drying the seed if it is to be stored.

When it is desired to have the dealer stratify the seed and treat it with repellents, costs for these treatments should be negotiated separately from the price of the seed. It is uneconomical to pay the same price per pound for stratified and repellent-coated seed as for untreated seed, because the treatments add great-

Figure 7.—**Why gomble on seed from trees of poor form?**

ly to the original weight of the seed and correspondingly decrease the number of seeds per pound when the seed is reweighed after treatment.

This may be illustrated as follows. Stratification adds about 25 percent to the weight of seed, and coating with repellents adds about 20 percent. The two combined increase weight by 45 percent, which means that 0.69 pound of untreated seed will weigh a full pound after treatment. At $4.00 per pound, 0.69 pound of untreated seed would cost $2.76. To pay $4.00 a pound for treated seed would be equivalent to paying $4.00 minus $2.76, or $1.24 for the treatments. Stratification usually costs about $0.10 per pound, or $0.07 for 0.69 pound, and repellent coating about $0.30, or $0.21 for 0.69 pound, or a total actual cost of only 28¢ instead of $1.24.

In summary, then, seed should be purchased dry, untreated, and with moisture content, purity percent, sound-seed percent, and viability specified. Stratification and repellent application should be priced separately.

Often the user can get better seed by collecting cones locally and having them processed in a commercial kiln than by buying extracted seed. By hiring and directing his own collecting crews, he can restrict collection, in any but poor seed years, to trees of better-than-average form and growth rate. Total cost of drying cones and dewinging and cleaning seed in commercial plants ranges from $0.50 to $1.00 per bushel.

It is also quite feasible for a landowner to process his own cones. Specialized equipment is required, but its cost can be recovered if a substantial acreage is to be sown. A small, forced-draft kiln now available for about $1,500 will efficiently handle 1,000 bushels of cones in a single season. Equipment for dewinging and cleaning costs an additional $400. Improvised facilities are usually unsatisfactory: they are seldom efficient, and are likely to damage the seed.

Loblolly seed can readily be kept for 5 years or more. High viability will be maintained if the seed is dried to 8 or 10 percent moisture content, placed in sealed containers, and stored at a temperature between 0°F. and 32°F. Four prerequisites for successful storage are: (1) collection of fully ripe cones, (2) careful storage of cones in a well-ventilated building to prevent molding before they go into the kiln, (3) processing of cones within 60 days after collection, and (4) placing the seed in cold storage immediately after processing.

The ease of storing loblolly seed makes possible substantial savings. Supplies collected in bumper years can be saved for use in lean years. Not only are cones cheapest when they are most abundant, but seed yields are greatest. Thus, in years of heavy cone crops, yields often average 1¼ pounds of seed per bushel of cones, as contrasted to ½ to ¾ pound when cones are relatively scarce.

SEED TREATMENT

Cold stratification

As loblolly seed invariably is dormant, cold stratification is needed to speed germination and thus reduce exposure to predators and adverse weather. Completeness as well as speed of germination is usually improved by cold stratification, though a small loss in total germination sometimes occurs. A reduction is most common with old, highly dormant seeds, which are in greatest need of stratification. But rapidity of germination is so important that stratification is essential even though it lessens viability.

Optimum length of stratification varies with seed lots. For this reason, comparative germination tests with sublots stratified for different periods are recommended. When this procedure is not feasible, the blanket prescription is to stratify for 60 days.

Cold stratification is simple and economical. There are several methods, but the most common is as follows:

> Cut the top out of a 55-gallon steel drum and punch a number of holes in the bottom to permit drainage of surplus water (fig. 8).

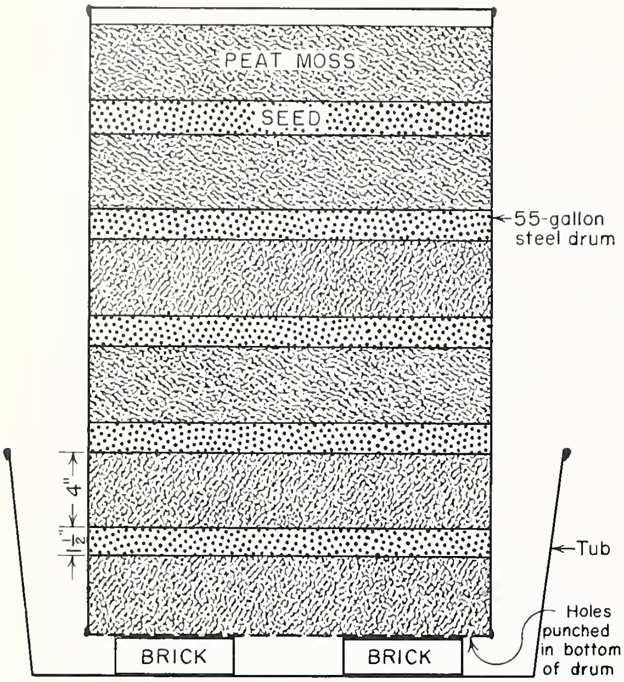


Figure 8.—**Section of drum and tub used to stratify seed.**

Set drum in a tub or pan and place three bricks under it (in the bottom of the tub) so that water can drain off freely.

Thoroughly soak granulated peat moss in water and pulverize all lumps.

Place 25-pound sublots of seed in large cotton sacks. Tie sacks with enough slack so the seed can be spread out to a uniform thickness in the drum.

Gently squeeze excess moisture from moss and place a 4-inch layer in the bottom of the steel drum. Tamp firmly.

Dip sack in water to wet the seed thoroughly and then place it on top of moss, spreading the seed inside the sack evenly in a layer 1 to 2 inches thick.

Add another 4-inch layer of moss to the drum, and tamp. Continue with alternating layers of seed and moss, and then cap off the drum with at least 4 inches of moss. Place drum in cold room at a constant temperature between 34° F. and 36° F.

Pour several gallons of water into the drum about every 2 weeks to keep the moss thoroughly wet, but not saturated.

After 30 days, and again after 45 days, remove sacks of seed from the stratification drum and inspect it for molding, heating, or spoilage. If excessive mold is found, wash and aerate the seed. When replacing the seed and moss, put sacks in layers other than the ones they previously occupied.

Each steel drum will hold 150 pounds of seed. Two men can easily put a ton of seed in stratification in a single day. The same amount of labor is needed to inspect a ton of seed and repack the drums.

Lots of less than 150 pounds can be stratified in like manner, but in smaller containers. If the lot is not more than 10 pounds, it can be stratified in a home refrigerator. Seeds are immersed in water until thoroughly wet and placed in a polyethylene bag; the bag is tied shut and then placed in a refrigerator kept at about 38° F. Water should be added when the surfaces of the seeds are dry, but only enough to rewet the seeds. This method is recommended for periods of 45 days or less.

Choice of repellent

A seed coating consists of a sticker, a bird repellent, and a chemical for controlling rodents and insects.

Four bird repellents—Morkit, anthraquinone, Arasan, and Arasan-75—have been effective, but only the last three are now available. Furthermore, Arasan-75 has largely supplanted Arasan in the last 2 years because it is easier to apply, is more durable, and has less dust because it is a wettable powder. Consequently, the present choice is between Arasan-75 and anthraquinone. Arasan SFM and Arasan SFX are toxic to pine seed and should never be substituted for Arasan-75.

Arasan-75 is about 30 percent cheaper than anthraquinone at the recommended dosages, but is so irritating to eyes, nose, and mucous membranes, as to be restricted to machine sowing, where workers are not exposed to the chemical dust. Anthraquinone, being non-irritating, is recommended for hand sowing.

The dosage for Arasan-75 is 10 pounds per 100 pounds of seed (dry weight). Anthraquinone should be applied at the rate of 15 pounds per 100 pounds of seed.

For protection against insects and small mammals, endrin must be blended with either of the bird repellents. The recommended rate is 2 pounds of Stauffer's Endrin 50W (or 1 percent effective endrin) to 100 pounds of seed.

To insure that all seeds receive the proper amount, the bird and rodent repellents must be thoroughly mixed before they are applied. A cement mixer will serve, but a better job can be done with special equipment at commercial chemical formulating plants, which are numerous throughout the South.

The sticker bonds the repellents to the seed. Both Flintkote's C-13-HPC asphalt emulsion mixed with water in a 1:3 ration (by volume) or Dow Latex 512-R diluted 1:9 with water are excellent. Latex is the easier to dilute and the cleaner to handle.

A list of current supply sources and approximate costs of repellents and stickers is available on request.

Applying repellents

The process of coating seed with repellents is simple and fast. With inexpensive equipment, three men can treat 2,000 pounds of seed daily. Careful attention to details, however, is essential to obtain a coating durable enough to withstand repeated rains and wide fluctuations in temperature.

The equipment consists of a drum for dipping seed into the sticker, a tumbling drum, a fine-meshed heavy wire basket, scales, and heavy waterproof paper or tarpaulins. A shed or well-ventilated building must be available for drying seed if bad weather prevents sun drying.

The dipping drum and the tumbler can be made from 55-gallon steel drums (fig. 9). The dipping drum has the top removed. The tumbling drum, for applying the chemicals, is mounted on an axle attached to a frame and rotates end-over-end with a crank. It has a tight-fitting lid and a single set of baffles welded inside to help mix the seed and repellents.

The wire basket is about 20 inches deep and just small enough to be lowered into the dipping drum.

Figure 9.—**Two steel drums can be modified into efficient treating equipment. A small concrete mixer may be easier to use than the homemade tumbler.**

Fifty pounds (dry weight) of seed are treated in each charge. If seed has been stratified with 25 pounds to a sack, further weighing is unnecessary. Otherwise, the ratio of stratified to untreated weight must be determined so that each sublot can be weighed out accurately. For example, if 1 pound of dry seed weighs 1.25 pounds after stratification, 62.5 pounds of stratified seed should be used in each charge. Similarly, the blended chemicals, in quantities sufficient to treat 50-pound seed lots, should be preweighed and placed in paper bags.

The sticker is mixed with water directly in the dipping drum. It should be thoroughly stirred at the beginning and restirred between batches. (When mixing asphalt, stir until all lumps disappear.) Hard or dirty water should not be used because it will break the emulsion. The sticker should be discarded at the end of each day's work and a fresh batch mixed the next morning.

After the sticker is mixed, pour 50 pounds of seed, dry weight (2 of the original 25-pound lots stratified in separate sacks), into the wire basket and lower it into the sticker. Stir the seeds with a wooden paddle so that they are thoroughly wetted. In about 2 minutes, lift the basket and allow the surplus sticker to drain off for about 30 seconds. Next, pour seed into the mixing drum, add the weighed repellent, and stir it into the seed with a paddle. Then close the cover tightly and rotate the drum for about 2 minutes. Finally, remove the coated seed and spread it out to dry in a layer 2 or 3 inches thick on paper or canvas.

Aluminum powder can be added to the coating to hasten drying, reduce dusting, and lubricate the seed so that it will flow through airplane hoppers more freely. It has no repellent qualities. Half a cup suffices for 50 pounds of seed. It should be added to the treating drum after the repellents have been mixed with the seed, and the drum tumbled for another minute.

The repellent coating must be dried enough to permit free flow through hoppers or sowing machines. On bright, sunny days, seed can be dried outdoors in 5 or 6 hours. During inclement weather, it should be spread out in a well-ventilated building and stirred periodically with a rake. Fans blowing over it will hasten drying. Seed can also be sacked and dried in a forced-draft kiln operating below 100°F.

A small cement mixer will serve when the sticker is latex. Twenty-five pound batches of seed can be treated in mixers of 2¼ cubic-foot capacity, while 3¼ cubic-foot models will handle 50-pound lots. The seed is placed in the mixer with enough diluted sticker to wet it thoroughly. About 2 quarts of sticker are needed for 50-pound lots. The mixer is operated for about one minute and then the weighed repellents are added. The mixer is run again for another 2 minutes, after which either the aluminum powder is added or the seed is removed to dry. Excess tumbling should be avoided because it tends to rub off the repellents. This method is satisfactory only for latex, as the asphalt sticker does not weather well unless seeds are immersed in it for several minutes.

Small lots can be repellent-coated with a lard can, a small wire basket made of window screen, and heavy-weight paper bags. One-pound batches are best in this method. Seed is placed in the wire basket and dipped into the sticker in the lard can. It is stirred with a wooden paddle for about 2 minutes, lifted out and allowed to drain for 30 seconds, and poured into a paper bag. A weighed quantity of blended repellents is put into the bag, which is closed tightly and shaken vigorously for about 60 seconds. If it is desired to overcoat with aluminum, one or two teaspoons of the powder can be added and the bag shaken again for about 30 seconds. Finally, the seed is spread out to dry.

It is reassuring to check the potential durability of the repellent coating before sowing, especially when seed treatment is being attempted for the first time. This can be done after drying is completed by putting several hundred seeds in a small wire basket and running a full stream of cold water from a faucet over them for 2 minutes. If more than two-thirds of each seed remains coated, the repellents will weather satisfactorily in the field. A greater loss of repellents indicates improper application and the seed should be retreated.

Most of the seeding failures in recent years have been traced to improper handling of the sticker. Trouble usually stems from excessive delay in applying the chemical repellent after the seed has been removed from the sticker. Draining of surplus sticker should be restricted to about 30 seconds because if the sticker is given time to set much of the repellent can be washed off by rains. Careful storage of latex is also important. It should never be kept in a metal container or at temperatures above 110°F. or below 32°F. The emulsion is easily broken through improper storage and cannot be recovered.

Men treating seed with repellents are exposed to considerable chemical dust even when working outdoors. Some workers are highly allergic to Arasan, and nearly all are irritated by it. Endrin is a poison that can be absorbed through the skin. Consequently, workers exposed to it should wear protective respirators, eye shields, rubber gloves and aprons, and tight-fitting clothes. They should wash their hands and faces thoroughly before eating, bathe at the end of the day, and change clothes before going home.

Treated seed can be stored safely for periods up to 2 weeks if bad weather prevents sowing. Cold storage at 34°F. is preferable, but seed can also be kept in a well-ventilated, unheated building. The bags of seed should be stacked to permit free circulation of air around each one, including those in the bottom course.

SEASON OF SOWING

For Louisiana conditions, the optimum date of sowing on most sites is mid-February. Sowing at this time will result in the earliest possible germination with the least seed exposure. For other regions, a good rule is to sow 2 weeks prior to the average date of the last killing frost. Ordinarily, this will roughly coincide with flowering of early species such as redbud and maple.

When sowing cannot be completed at the optimum time, it is preferable to sow too early rather than too late. The danger of late sowing is the possible onset of an early spring drought that will reduce germination or kill the seedlings before their roots are well developed. The chances for adverse conditions usually increase as the season advances. On the other hand, sowing several weeks prior to the optimum date involves no special danger other than some unnecessary stress on the repellents, because seed will not germinate until maximum daily temperatures begin to reach 75°F. At that time, the risk of killing frosts is about over.

Special conditions may justify delays up to 45 days. For example, in southwest Louisiana several landowners sow in late March, when drying begins on flat, wet sites that have standing water most of the winter. Similarly, the likelihood of late winter floods in or adjacent to creek bottoms may dictate sowing later than normal.

Fall sowing of unstratified seed was recommended at one time for sites dominated by low-grade hardwoods. The seed, partially hidden by leaves, stratifies on the ground during the winter and germinates promptly in the spring. But it now seems safer to sow stratified seed in February, as overwinter exposure weakens the repellents. Stratified seed never should be sown in the fall because seedlings that might germinate would be winterkilled.

METHODS OF SOWING

Loblolly can be sown by hand, by hand-operated "cyclone" seeders, by airplane, by helicopter, and by tractor-drawn machines.

Hand sowing

Distribution by hand is efficient on small areas disked in strips. One man can cover 15 to 20 acres per day, and seed is conserved because it is cast only on the disked portions.

The "cyclone" hand-operated seeder (fig. 10) is useful on tracts up to 200 acres in size. Its greatest utility is on areas that are irregular in shape or that have scattered patches of established pines. Crews can quickly be trained to broadcast seed uniformly, and one

Figure 10.—

A hand "cyclone" seeder is economical on small tracts. (Photo by Louisiana Forestry Commission.)

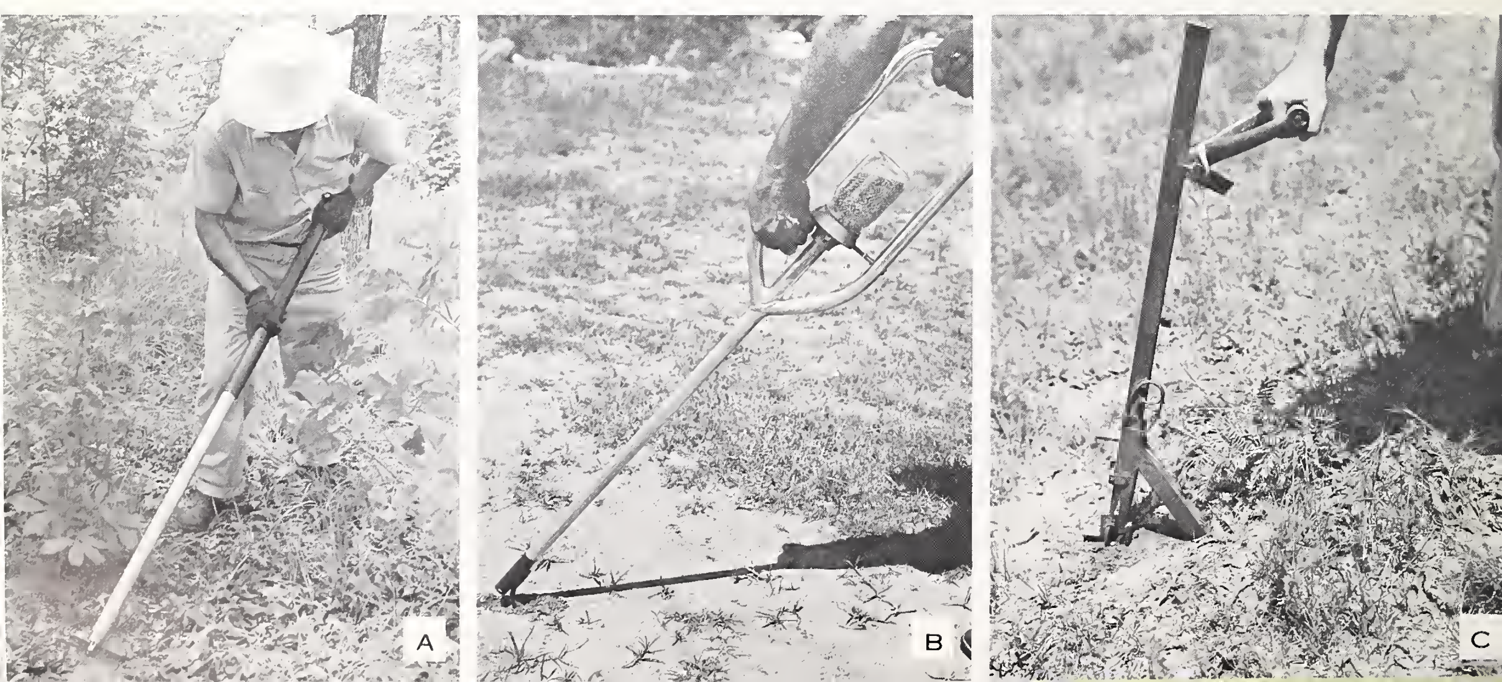
man can sow 20 acres daily on open land with good terrain.

The chief disadvantage is exposure of workers to dust from the repellent coating. Use of anthraquinone instead of Arasan will eliminate skin irritations. Aluminum overcoating will reduce dusting and minimize the danger from endrin. Careful washing before eating and at the end of each day also is a necessary safety precaution.

Spotting is an old method that is being reevaluated by many landowners. A spot about 1 foot square is raked or kicked free of leaves or grass, and 5 or 6 seeds are dropped on it and very lightly pressed into mineral soil. About 1,000 spots per acre are needed. It is estimated that one man can sow 2 to 4 acres daily if the underbrush is light. Although spotting appears impractical for large areas, it should be generally useful on small tracts.

A number of special tools have been developed for spotting. Most have a device for baring mineral soil and a mechanism for metering a predetermined number of seeds on the prepared spot (fig. 11). They sell for

Figure 11.—**Three seed-spotting tools. A and B rake a clean spot, while C opens a small hole in the ground with 2 metal jaws.**



$15 to $30. Each model has features that adapt it to special soil and cover conditions. A short-handled firerake and an apron for carrying seed probably are also adequate for most operations (fig. 12).

Figure 12.—**A short-hondled fireroke is o proctical tool for preporing spots on areas with heovy litter.**

Rubber gloves should be worn for all hand seeding.

Airplane sowing

Fixed-wing aircraft, used extensively for direct seeding in the past 5 years, have consistently given excellent distribution and precise showing rates (fig. 13). Their chief advantage is the ability to broadcast large areas quickly when weather is optimum for prompt germination. Another advantage is that labor requirements are small. With a ground crew of 3 or 4 flagmen and 2 men to weigh and load seed, a light plane can cover 1,200 to 1,500 acres daily. Capital outlay for the landowner is negligible.

Airplanes also have drawbacks, some of which can be overcome by careful planning and reasonable precautions. Bad flying weather causes expensive delays and problems of storing stratified, treated seed. The possibility of errors in sowing rates is always present, but can be minimized by screening seed before it is placed in the hopper, by methodical calibration of the plane, and by limiting each flight to 100 acres or less. Seed is often wasted on hardwood bottoms or upland areas with adequate pine reproduction. This, too, can be largely avoided by careful site inspection, accurate maps, and close supervision of the pilot.

Any type of plane used in agricultural pest control can be adapted to direct seeding if slight modifications are made in the gate of the hopper. Most planes have long gates that can be opened wide for heavy applications of fertilizer or insecticide. When the gate is closed enough for pine seeding, the opening is so narrow that it often clogs. The solution is to set the opening wide enough to allow free flow of pine seed but to block off enough of the length to achieve the proper sowing rate.

Figure 13.—
Large trocts con be sown quickly ond economicolly by fixed-wing plones.

Figure 14 shows an inexpensive method of converting the narrow slot into 4 wider, adjustable openings by blanking-off part of the gate with plates installed in the bottom of the hopper. The plates are wedge-shaped to help divert seed toward the openings.

Piper P18A planes have two openings between the hopper and distributor, each controlled by a separate gate about 10 inches long. Here again it is necessary to block off much of the gate length in order to have the seed pass through wider holes. This is accomplished by inserting, above each gate, a fixed plate having 2 holes, each 1 inch square. Flow through these openings is then adjusted by regular movement of the gate. A necessary preliminary to this modification is to synchro-

Figure 14.—**Hopper with part of gate blanked off for loblolly seeding.**

nize the two gates so that they open the same amount.

Costs of airplane sowing have ranged from \$0.40 to \$0.90 per acre, depending on the acreage seeded and the location of a landing strip. Construction of a temporary dirt strip on the seeded area has been profitable in several instances where other landing facilities were 8 or 10 miles away.

Helicopter seeding

Small helicopters, like the Bell 47G-2, have been used extensively for seeding, and with

Figure 15.—**Helicopters can operate from small clearings and the landowner can ride with the pilot.**

excellent success. Most landowners who have used different types of aircraft believe that helicopters distribute seed more uniformly than airplanes, although both are satisfactory.

In good weather a helicopter can sow 2,500 acres daily. The swath is 99 feet wide, as compared to 66 feet for airplanes. The craft can operate from small, level clearings; hence, little time is lost in ferrying. Because the seed is thrown out with a revolving slinger (fig. 16), altitude while sowing is not so important

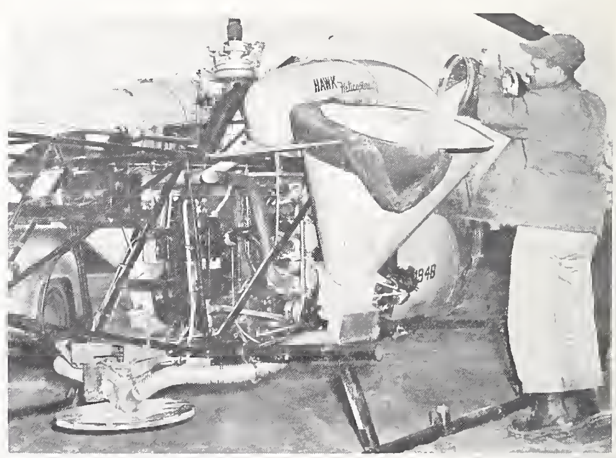
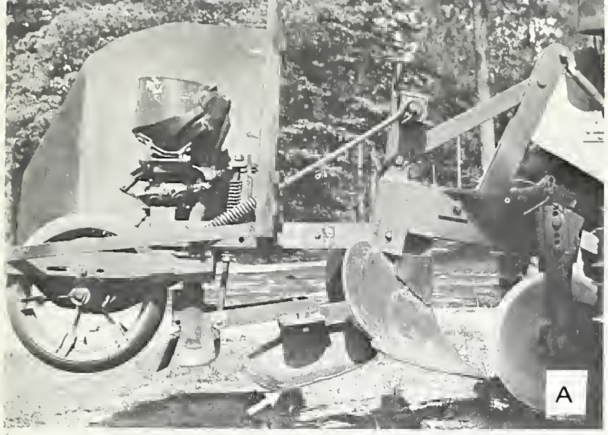
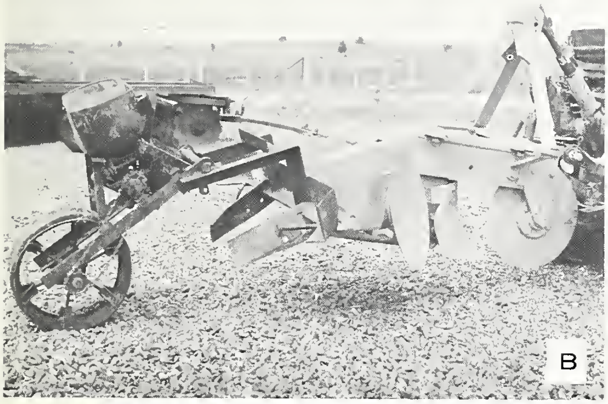


Figure 16.—**Seed from a helicopter is distributed through a slinger mechanism (at lower left in photo) over a 99-foot swath.** (Photo by Elemore Morgan for T. L. James and Company.)





as with airplanes. A big advantage of the helicopter is that the landowner can ride with the pilot and direct the entire operation.

Contract prices for the Bell helicopter vary with the acreage to be seeded. Usually they average $0.10 per acre more than the cost of an airplane. Greater daily production, however, results in enough savings on flagging to offset the higher rental.

Tractor seeding

At least 10 models of tractor-drawn seeding machines have been developed in the last 5

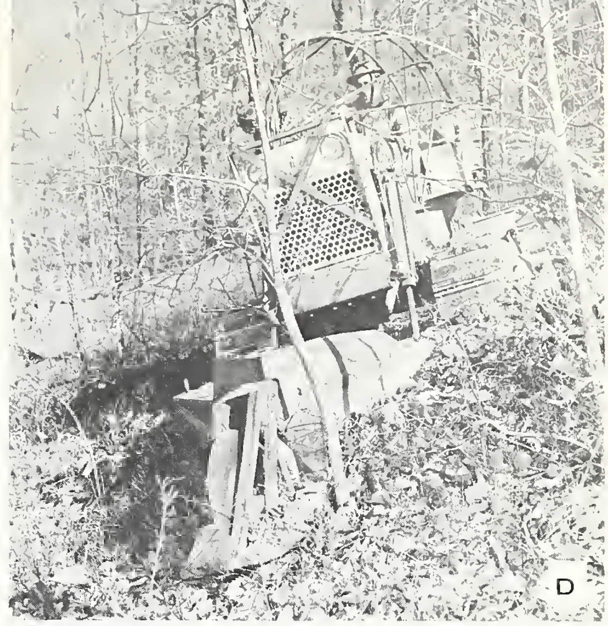


Figure 17.—**Four furrow seeders that have been used in various parts of the South.**

A.—Adjustable hillers (indicated by arrow) on the H-C seeder may be replaced with an agricultural sword.

B.—This seeder works on the same principle as the H-C, but the hillers are fixed in place.

C.—Front-end seeder with hopper in center of V-blade operates in heavy brush.

D.—Furrowing device is the same as in C, but sowing is on spoil after tracks have packed it down. (Photo courtesy Ernest Hinson.)

years, and new ones continue to appear. All have one feature in common: they prepare a seedbed and sow in rows at a single pass. Otherwise, they are so diverse and numerous that a full description of each is impractical.

Furrow seeders, the most common kind, are of 2 types. One has a middle-buster plow pulled by the tractor; the other has a plow mounted on the front end of the tractor.

Those pulled by a tractor scalp a shallow furrow and elevate a narrow mound within the furrow with a set of hillers (fig. 17A and B). Seeds are dropped from a hopper at predetermined intervals onto the mound and pressed by a packing wheel. Elevating the row reduces the chance of loss from prolonged flooding, and rolling the seed into contact with the soil improves germination. In another model the hillers are replaced by an agricultural sword. The sword opens a shallow trench for the seeds and the packing wheel covers them with soil. This modification is intended for light, sandy soils where the seed must be covered lightly to obtain complete germination.

Front-end furrow seeders work best on sandy soils. They can be operated on brushy sites where the use of other types is limited. With one model (fig. 17C), seeds are dropped directly into the furrow and are pressed down by a packing wheel. Another model has a cutaway V-plow that pushes the soil directly into the path of the tractor tracks (fig. 17D). The weight of the tractor packs the loose soil and seeds are sown on each ridge from hoppers mounted on the rear of the tractor.

All types of furrow seeders will sow from 15 to 20 acres daily. Their main advantage is low cost per acre, resulting from combined seedbed preparation and sowing in a single operation, and from reduced seeding rates. The fact that they establish trees in rows may also be advantageous, but spacing within rows is not easily regulated, and this may retard growth. Disadvantages include: (1) high capital outlay for tractors and machines, with consequent temptation to sow beyond the optimum date in order to utilize machines fully; (2) rough condition of the ground after seeding; (3) displacement of topsoil (probably a serious drawback only on sites where fertility is low); and (4) limited utility—they perform best on sandy, level sites (some models are restricted to cleared or open sites).

Disk seeders were developed to sow two rows simultaneously with the same tractor power required for single-row furrow seeding (fig. 18A). They are also made in 1-row models, for maneuverability in hardwood stands (fig. 18B). Two separate offset disk units, each 1½ feet wide, are mounted 4½ feet apart (edge-to-edge) on a tool bar behind the tractor. Behind each set of disks are packing wheels and seed funnels. A disk seeder can sow about 30 acres a day, and operates fairly well on a wide variety of soils. Sowing rates must be higher than with furrow seeders, because considerable seed is lost from silting on all soil types. These machines are too new for full appraisal, but disking in the cool, wet part of the year appears to be ineffective for reduction of grass competition. Many of the objections and advantages noted for furrow seeders also apply.

One of the earliest tractor-drawn row seeders deserves mention because it employed a rotatiller instead of a plow or disks. The rotatilled bed was 14 inches wide and 1½ inches deep. Seeds were dropped onto the bed from a hopper, and not covered or packed. Use of the machine was discontinued in 1955, after several years, because it could operate only on areas free of debris and roots.

Power-driven "cyclone" seeders are sometimes mounted on tractors to broadcast seed. They are useful where brush is too dense for crews with hand seeders or when it is necessary to avoid excessive exposure of personnel to the chemical dust from the seed. As a light tractor can cover from 30 to 50 acres daily, the cost is comparable to hand seeding.

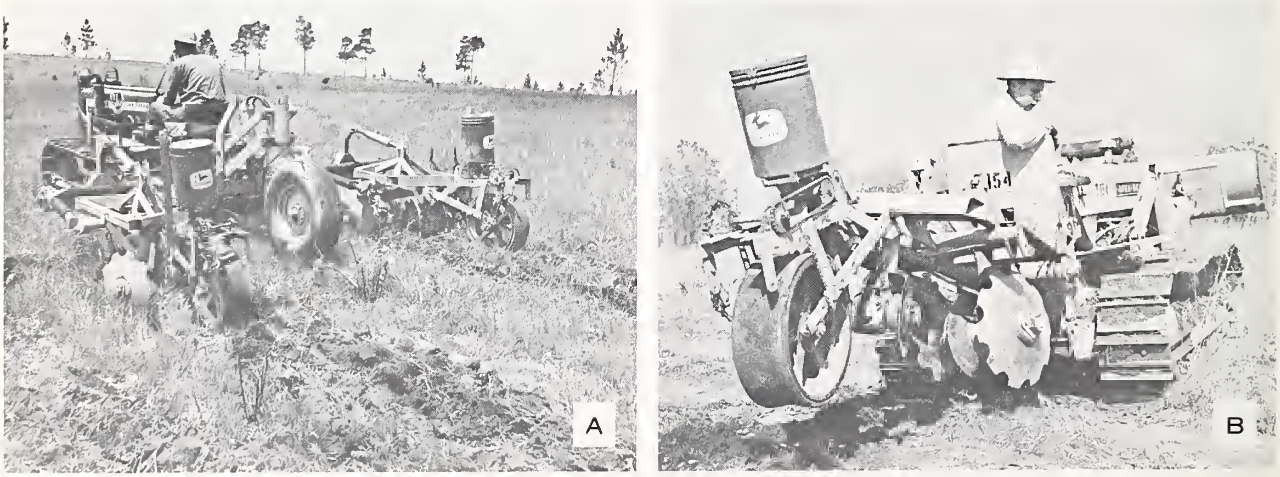


Figure 18.—**Disk seeders have offset disks for flat-breaking.**

A.—The 2-row model covers 30 acres a day in open country.

B.—Single-row machine for operating among hardwoods. An innovation is that the disks are of graduated size. (Photo by Elemore Morgan for T. L. James and Company.)

RATE OF SOWING

Recommended sowing rates per acre are 1 pound when broadcast, ¾ pound for disk seeding, and ½ pound for furrow seeding. These weights are in terms of seed before stratification and repellent-coating, and at least 80 percent viable.

When well cleaned, loblolly seed numbers about 17,500 to the pound. Initial catches (stands in May before the start of hot, dry weather) in commercial operations over the last 4 years have averaged about 5,000 seedlings per acre from 1 pound of seed. This is not considered to be excessive, because first-summer mortality on experimental plots has often reached 80 percent in dry years, even on disked seedbeds. Therefore, consistent success in loblolly seeding is dependent on high initial catches that can be achieved only by sowing the recommended rates.

Some landowners have reduced rates 30 to 50 percent to cut costs and to avoid overdense stocking in favorable years. Usually they have obtained satisfactory stands, because summer weather over much of the South has been generally good since commercial seeding of loblolly started in 1957. In Louisiana dry summers can be expected about 5 years in 10, however, and sowing rates should be cut only when it is clearly understood that the chances for success are lessened by doing so. The best plan for those starting to seed is to use recommended rates for several years and gradually reduce them if experience in specific areas shows that it can be done safely.

CALIBRATING SOWING EQUIPMENT

Any of the machines described will sow loblolly accurately and uniformly if the repellent coating is dry, and if trash and clumps of seed (stuck together with the repellents) have been screened out. Putting seed through ¼-inch hardware cloth immediately before it is placed in a hopper will insure against clogging.

Calibration of machines for broadcast sowing (aircraft and cyclone seeders) and subsequent checking are accomplished by area control. In other words, a predetermined quantity of seed is broadcast on an area of known size, with the assumption that distribution is equally good over the entire area. Procedures for calibrating a fixed-wing airplane are as follows:

> Determine the ratio of dry seed to stratified repellent-treated seed. Ordinarily, the weight gain will average about 45 percent; that is, 1 pound of untreated seed will weigh 1.45 pounds after it has been stratified and coated.
>
> Select three 20-acre areas with regular boundaries and measure off 1-chain flight strips on each end of the area to guide the flagmen. A 66-foot swath has given excellent seed distribution with all airplanes used so far.
>
> Open the hopper gate ¼ inch. If the plane has twin gates, set both for the same opening. Check gate to be certain it opens the same width each time, because loose linkage is found with almost all airplanes.
>
> Weigh seed needed for 20 acres. Add 20 pounds extra for a reserve in the hopper. Screen seed before it is loaded into the plane.
>
> Sow the 20-acre test area crosswind at normal speed. Flying parallel to the wind results in varying ground speeds and differential sowing rates.
>
> Weigh seed remaining in hopper to determine accuracy of sowing. Adjust as needed, and sow another 20-acre test area in the same manner. Three flights ordinarily will calibrate an airplane satisfactorily. A pilot experienced in direct-seeding often sets the hopper gate correctly on the first or second try.
>
> Once the airplane is calibrated, gradually increase the area sown on each flight to 100 acres. Seeding more than 100 acres per flight is risky, because mistakes in the sowing rate are almost impossible to correct.

Calibration of helicopters and of hand or tractor-mounted "cyclone" seeders follows the same general pattern. Helicopters seed a 99-foot swath, hand seeders 16¼ feet, and tractor-mounted seeders about 40 feet. A calibration area of 1 acre is adequate for hand seeders; a strip ½-mile long is equivalent to 1 acre. For tractor-mounted cyclone seeders, 5 acres (a strip 5,450 feet long and 40 feet wide) are enough.

Small adjustments in hopper openings are usually required during the day as the relative humidity changes. Absorption and loss of moisture by the repellent seed coating influence the rate of flow.

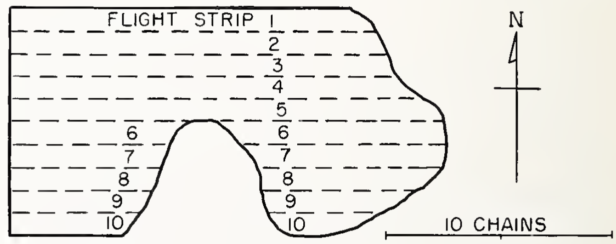
Aerial seeding should not be attempted when winds are gusty or exceed 10 miles per hour. Crosswinds have little or no effect on the width of the seed swath, but they change the pattern, shortening the distribution upwind and extending it downwind. Sowing in gusty winds must be avoided because the aircraft flies an irregular course and differential drift of seed results in erratic distribution.

A plane's altitude has some effect on the width of the swath. Flying at heights of 80-125 feet will give good distribution if ridges are cleared by 60 feet. Below this level, strip width narrows excessively. Helicopters can operate at altitudes as low as 10 feet because the seed is thrown out the full width by the slinger mechanism.

Flagmen must be used to guide flights of aircraft. For accurate alignment, the pilot needs to see at least two flags, other than the one directly below the ship, after completing each turn. Usually three flagmen are sufficient, but more may be needed if the terrain is rolling or tall trees obstruct the pilot's view. Flags, mounted on long bamboo poles, should be a distinctive color and they should be kept in motion at all times when the plane is approaching.

It is best to measure and mark flagging points on the ground in advance. When flagmen pace off distances between strips, they often get out of alignment and the pilot then has difficulty in determining the correct flight line.

A map showing flight lines and the acreage in each swath facilitates the entire operation (fig. 19). With this information the acreage



Specifications:
Flight strips: 1 chain wide (airplane sowing)
Sowing rate: 1 pound per acre (untreated, unstratified)
Weight ratio of treated to untreated seed: 1.4 pounds

Flight strip	*Acres*	*Treated seed needed (pounds)*
1	1.6	2.2
2	1.7	2.4
3	1.7	2.4
4	1.8	2.5
5	1.9	2.7
6	1.6	2.2
7	1.5	2.1
8	1.4	2.0
9	1.2	1.7
10	1.0	1.4

Figure 19.—**Plans for aerial seeding should include a map of proposed flight strips, with acreage and seed requirements noted for each strip as shown on this small example.**

to be sown for each takeoff and the seed needed are quickly determined, and the pilot can be told how many strips to fly before returning for more seed.

Tractor-drawn seeders are calibrated by checking the number of seeds dropped on 100-foot segments of prepared bed. For example, a rate of ½ pound per gross acre on plowed furrows spaced 8 feet apart (center-to-center) requires 320 seeds on a 100-foot segment if the lot contains 17,500 seeds per pound.

OBSERVATIONS AFTER SOWING

In initial trials it is quite important to inspect seeded areas systematically during the germination period. This is the only way to determine if unusual predators are present,

and to pinpoint the cause of failure when stocking is low. After several successful trials, these observations usually can be discontinued.

Because loblolly seed is difficult to find after a few rains, observation stations are helpful in checking the progress of germination and determining the extent and causes of seed and seedling losses. A station that has given satisfactory results consists of an identification stake, 50 extra seeds sown within 18 inches of the stake, and 2 seed spots screened to keep out predators. Screened spots should be several feet from the stake on level ground where the seeds cannot wash away. Window screening or hardware cloth with ¼-inch mesh makes satisfactory covers when fastened down firmly. The number of stations depends on the size of the area. If well distributed, 50 are sufficient to detect major depredations on areas up to several thousand acres. One man can inspect this number in a day.

Stations should be checked weekly until most seeds have germinated and shed their coats. Progress of germination, number of seeds and seed hulls found, and type of damage should be noted for each station during the weekly inspections.

Birds and other large predators take loblolly seed whole, leaving no remnants for identification. Tracks or droppings will sometimes afford a clue to their identity. Rodents and shrews characteristically crack the seed in half like clamshells, to get the endosperm, but the remnants are so much alike that they offer little clue as to the predatory species (fig. 20).

Figure 20.—**Rodents of all species split loblolly seed in a similar manner.**

New seedlings are often clipped off near the groundline and the severed portions carried off or eaten. Clipping is most common in March, and the first seedlings to become established are hardest hit. However, total losses rarely exceed 10 or 15 percent. Unless seedlings on the observation stations are marked with pins immediately after germination these losses may go undetected. Rabbits, shrews, and crickets probably are responsible in most cases. If crickets are the culprits, pieces of the cotyledons can be found in the upper food chamber of their burrows. Rabbits and shrews will consume seedlings immediately after clipping them.

Ants also destroy seeds and seedlings. Harvester ants carry large numbers of seeds into their nests. Town ants take portions of the germinating seed and sections of seedlings to their colonies. Ants of several other species cause minor damage by feeding on endosperms after the seed cracks open for radicle emergence.

SEEDLING INVENTORIES

Two seedling inventories should be taken during the first year. The first is made in May to evaluate the efficiency of repellents against local predators and the effects of weather on germination, and to determine if release should begin from unwanted hardwoods.

Because first-summer mortality may be high a second inventory is required in the winter following seeding. It measures the success or failure of the operation, for losses after the first year are negligible. It is preferable to use the same sample plots in both inventories.

The number of plots needed to estimate stocking depends on the accuracy desired and the plot-to-plot variation (expressed as the coefficient of variation) in numbers of seedlings. Size of area seeded and size of sample

plot influence the coefficient of variation. Experience indicates that, with plots of the size suggested here, a coefficient of variation of 100 percent may safely be assumed for areas up to several thousand acres. The formula for computing intensity of sampling with 67-percent reliability is:

$$\text{Sample plots needed} = \left(\frac{\text{coefficient of variation}}{\text{accuracy desired}}\right)^2.$$

If a landowner chooses to sample for $\pm$ 10 percent accuracy, the number of plots would be:

$$\left(\frac{100}{10}\right)^2 = 100.$$

When seeding rates, methods of sowing, or sites vary within an area, it is desirable to inventory homogeneous sub-blocks separately. Similarly, more intensive sampling is needed when accurate estimates for sub-units (i.e., by forties) are required.

For broadcast sowing, circular milacre plots equally spaced over the area are satisfactory. Average plot stocking multiplied by 1,000 provides an estimate of seedlings per acre. Distribution is expressed as the proportion of sample plots with one or more seedlings. These two statistics are closely related: adequate distribution is rarely obtained with less than 750 seedlings per acre.

Estimates on broadcast-sown disked strips require a modified technique. Two milacres—one on a disked strip and one on an undisked balk—are used at each sample location. The distance between disked strips (edge-to-edge) at each location is measured to determine the proportion of the area that is disked. To obtain overall stocking, average stocking on disked and undisked milacres is weighted by the area represented by each.

Where sowing is confined to rows, as on plowed furrows or on disked strips, inventories are made differently from those on broadcast areas. Sample plots, located mechanically over the area, consist of a 13.2-foot segment of a row or strip. This plot is divided into two 6.6-foot subplots and the number of seedlings on each is recorded separately. Distances from the center of the sample strip to the center of each adjoining strip are measured at each location to adjust average stocking to a gross acre. Seedlings per gross acre are estimated by multiplying the average stocking for 13.2-foot plots by

$$\frac{3{,}300}{\text{averaged distance between disked or furrowed strip centers}}.$$

Thus, if average stocking per 13.2-foot plot is 5 and rows are 10 feet apart:

$$5 \times \frac{3{,}300}{10} = 1{,}650 \text{ seedlings per acre.}$$

The constant, 3,300, is derived by dividing 43,560 (square feet per acre) by 13.2. If the size of the sample plot is changed, a new constant must be calculated.

Stocking percent based on 1,000 perfectly spaced seedlings per acre is obtained by multiplying the percent of stocked subplots (6.6-foot segments of strip) by

$$\frac{6.6}{\text{average distance between strip centers}}.$$

With this method, full plot stocking is less than 100 percent when the average distance between strips exceeds 6.6 feet. Maximum stocking obtainable with strips on 10-foot centers is:

$$100 \times \frac{6.6}{10.0} = 66 \text{ percent.}$$

The impact of strip spacing on subsequent seedling distribution should be carefully weighed when planning a seeding operation.

In seed-spot operations the simplest method of inventory is to determine the proportion of spots with at least one seedling. As more than one seedling per spot is excess stocking, it is unimportant to calculate the stand per acre. If the spots cannot be found readily, stocking can be estimated from mechanically spaced milacre plots.

SEEDLING RELEASE

On areas with overtopping hardwoods, pine seedlings must be released early in the first growing season. Delay until late in the first year or until the second year jeopardizes estab-

lishment of the stand and retards growth. The need for prompt release is most urgent on droughty sites and where dense, small hardwoods cast low shade.

The best procedure is to start hardwood control immediately after the May inventory, provided that there are sufficient seedlings to justify the work. If possible, all release should be completed before hot summer weather begins. Where a large area is to be treated, it is advisable to schedule the critical sites first, leaving work on better soils and in relatively open hardwood stands until last.

First-year release is advocated because studies by the Alexandria Research Center have consistently shown that delay lessens pine growth. Unreleased year-old loblolly pine seedlings typically average 3 inches tall, while those freed from hardwood competition before July average 9 to 18 inches (fig. 21). These studies also have shown that timely release markedly improves survival on dry sites, and on all sites in dry years. The most compelling purpose of early, first-year release is to prevent complete loss of seedlings in an adverse summer.

Any method of deadening hardwoods can be employed except foliar sprays that kill succulent yearling pines. As a general rule, it is best to use a chemical to inhibit hardwood sprouts that may resuppress pine seedlings.

Figure 21.—
These 1-year-old seedlings demonstrate the need for early removal of overtopping hardwoods. Pair on right was released in June, other pair was unreleased.

COSTS

Costs, time requirements, and production estimates have been mentioned for many phases of the seeding job. The purpose of this section is to consolidate and summarize costs for the situations that are most often encountered. While the summaries will give realistic estimates of average costs, it must be recognized that size of the operation, individual efficiency, and price of seed introduce considerable variation.

Because a number of economies are possible in large-scale work, per-acre costs usually are lower for seeding large tracts that small ones, site and cover conditions being equal. Costs for burning, flying, and seed all decrease with increasing acreages. Data given here are for tracts 300 to 1,000 acres. Landowners seeding less than 100 acres should increase these estimates by 20 percent. On larger tracts, costs may be 10 to 15 percent less.

Seed is the largest single item of expense. Many landowners have been able to lower seed costs $1.00 to $2.00 per acre by collecting their own cones and having them processed in commercial kilns. This procedure also tends to stabilize costs if cone collections are confined to bumper years and seed is stored for use when cones are scarce. The price in the following estimates, $3.25 per pound, is the average for purchased seed in Louisiana during the past 4 years. Added to this is $0.10 per pound for cold stratification and $0.30 for repellents and the labor to apply them—for a total price of $3.65 per pound.

Labor rates are $1.00 per hour plus $0.25 per hour for insurance, social security, and the like. No allowance is included for supervision and overhead.

Broadcast sowing 1 pound of seed per acre on open areas disked in strips:

	Cost per acre
Burning	$ 0.10
Disking	2.00
Seed (treated)	3.65
Aerial sowing	.50
Flagging of aircraft	.15
Total	$ 6.40

Furrow seeding open areas with ½ pound of seed per acre, assuming daily production of 15 acres:

	Cost per acre
Burning	$ 0.10
Seed (treated)	1.88
Furrowing and seeding	2.50
Total	$ 4.48

Broadcast sowing 1 pound of seed per acre on hardwood areas, with no allowance for hardwood removal:

	Cost per acre
Burning	$ 0.50
Seed (treated)	3.65
Aerial sowing	.50
Flagging	.20
Total	$4.85

Seed spotting on hardwood areas, 5 seeds on each of 1,000 spots, with no allowance for hardwood removal:

	Cost per acre
Seed (treated)	$ 1.22
Distributing seed (3 acres per man-day)	3.33
Total	$ 4.55

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